THE STRAWBERRY ROOT WEEVIL

WITH NOTES ON OTHER INSECTS AFFECTING STRAWBERRIES

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DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
PAMPHLET NO. 5—NEW SERIES
(Second Revised Edition)

THE ENTOMOLOGICAL BRANCH
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Published by direction of the Hon. Robert Weir, Minister of Agriculture,
Ottawa, March, 1931

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1931

The Strawberry Root Weevil with notes on other Insects affecting Strawberries

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INTRODUCTION

The small fruit industry in British Columbia, during recent years, has been growing steadily in importance, the acreage under strawberries having greatly increased and similar increases have taken place in the case of other small fruits.

In response to the demand for further information as to the control of the Strawberry Root Weevil, arrangements were made with the Provincial Government of British Columbia, in 1918, for the use of six acres of land in the centre of the strawberry-growing district of Gordon Head, Vancouver island, B.C., with a view to demonstrating systems of crop rotation suitable to strawberry culture and to elucidate still further if possible the problem of weevil control. Much of the information respecting the life-history and further light on control methods, have been obtained there.

Hitherto, the small fruit grower has paid little attention to the control of insects affecting his crop, compared to that given to tree fruits. Of late, however, many examples of the damage that can be caused by pests which are allowed to spread unchecked, has caused a greater appreciation of the benefit which accrues from the employment of proper methods for their control. A certain amount of outlay on such measures should be regarded by the growers as a necessity if small fruit culture is to be made a commercial success.

Among the small fruit pests, the chief problem which has confronted the growers for a number of years is the control of the Strawberry Root Weevil (*Brachyrhinus ovatus* L.), which has become thoroughly well established in the province of British Columbia. The Black Vine Weevil (*Brachyrhinus sulcatus* Fab.) is also present in limited numbers and in some locations where conditions are suited to it, may cause considerable damage. A third species, [*Brachyrhinus rugosotriatus* Goeze (*rugifrons* Gyll.)], has been recently found to be present on the lower mainland of British Columbia, and also occurs in the city of Victoria on Vancouver island. Of the three species mentioned, *B. ovatus* is by far the most prolific and destructive, and in the present pamphlet it is this species which is principally dealt with. The habits of all three species, however, are so similar that the control measures advocated will apply to all.

THE STRAWBERRY ROOT WEEVIL (*Brachyrhinus ovatus* L.)

In point of importance as a strawberry pest this insect easily takes first place on the Pacific coast. There seems to be no doubt that the beetle is a native one. It is present in all the settled portions of the southern part of the province and has been found on rocky islands away from settlements where it could not possibly have been introduced artificially, and at various altitudes up to 4,000 feet in the mountains. Instances have occurred where isolated bush farms, some miles removed from the nearest settlement, have had their strawberry plantations badly infested after being planted but a short time. Under natural conditions various factors militate against the abnormal increase of the weevil, the chief of which are, no doubt, predacious enemies and the absence of favourable soil conditions which would make an abundance of food available for the young grubs. Under conditions of cultivation these restrictions are removed and the beetles find in the cultivated strawberry an unlimited

supply of an ideal food plant together with soil that has been reduced to a fine tilth, making it easily penetrable by the larvæ. Certain it is that the weevil is present in the province of British Columbia wherever strawberries are grown and its steady increase and the consequent decline in the yield of the plantations is a matter of grave concern to the growers.

Symptoms of attack.—A field of strawberries attacked by the weevil usually exhibits the following features: Instead of showing a vigorous growth in the spring the plants have a stunted appearance and the leaves are closely bunched together and take on a dark bluish-green colour. This should not be confused with the stunted and unhealthy growth caused by water at the roots which produces a somewhat similar appearance. If an examination is made all the fine feeding roots of the plant will be found to have been destroyed and nothing remains but a few hard fibrous roots and the crown, and even the latter may be partly eaten in the case of a heavy infestation. An examination of the soil will reveal numbers of small white grubs about a quarter of an inch in length, which are the larvæ of the weevil. Those plants which survive a heavy attack will produce a poor crop of undersized berries and later in the season with the advent of hot weather, the plants being without any root system whereby moisture can be drawn from the subsoil, will wither and die. The injury to the plants is practically all done by the grubs, the adults being responsible only for slight ragging of the leaves and stems which, when the beetles are present in large numbers, are nibbled in a characteristic manner. The adult beetles will also attack the fruit to a limited extent, eating small holes into the same and rendering it unmarketable.

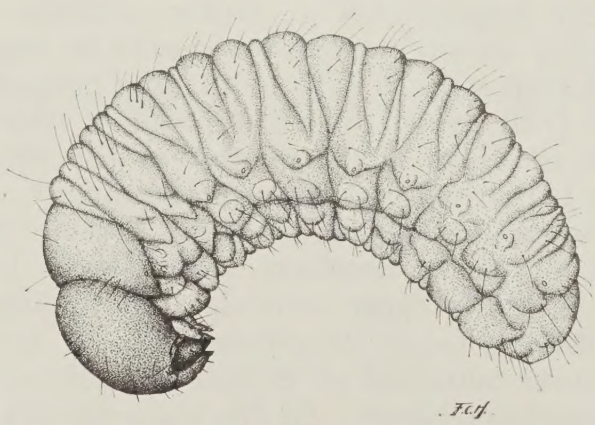

FIG. 1.—Larva of Strawberry Root Weevil.
Greatly enlarged. (Author's illustration)

The egg.—"The egg is very minute, almost spherical, breadth ·25 mm. When freshly laid it is milky white in colour, changing after a day to a pale shade of brown; the ensheathing membrane is hard and firm, and there does not appear to be any mucilaginous material on the exterior to retain it securely in the position it may be deposited in the soil or on the crown of the plant."[1]

In our observations at Victoria, B.C., we have found that sometimes a great many of the earliest eggs laid in the spring are infertile, but the percentage of fertility increases as the season advances.

The larva.—"When newly hatched the larva is slightly longer than the egg from which it emerged and measures .5 mm. It is a characteristic weevil larva in shape and colour. The body is slightly covered with minute hairs, is slightly curved, whitish, with a head of the same colour, but smooth. In a short time the head assumes a light shade of brown, the body remaining white, sometimes coloured pink or grey from the nature of the contents of the intestines. As the age of the larva increases the same characteristics are retained, the mouth parts, however, assuming a darker shade of brown than the colour of the head."[1]

[1] Treherne, Ent. Bull. 8, Dom. Dept. Agr., Ottawa, 1914.

When full grown the larvæ measure three-eighths of an inch long by one-eighth of an inch wide, and are slightly tapering and usually pure white in colour except the head which is brown. They lie in a curved position in the soil and their appearance is fairly distinctive.

The larval stage usually lasts from about late summer until the following May when the grub transforms to a pupa.

The pupa.—The pupa is very soft and delicate and lies in a little oval cell formed by the larva prior to transformation. It is milky-white in colour and the various appendages of the adult are apparent, the wing pads, legs and antennæ, folded on the ventral surface of the body. It is capable of only partial movement and twists its caudal segments round and round when disturbed. When transformation to the adult state takes place, the eyes of the perfect insect appear as two black spots on the head and after a few days when the adult has fully developed, the pupal membrane sloughs off.

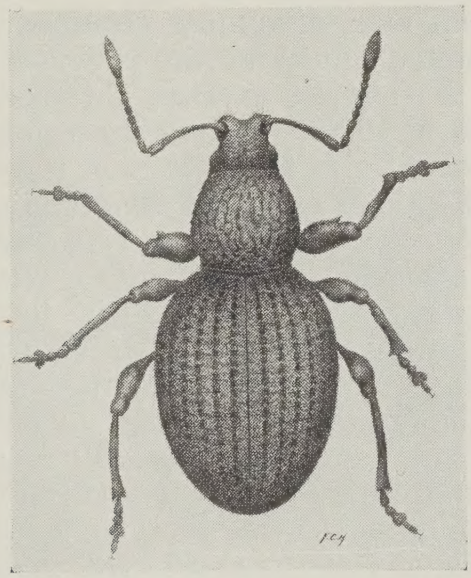

FIG. 2.—Strawberry root weevil, greatly enlarged. (Author's illustration)

The adult beetle.—"The adult, when fully developed, is dark brown, almost black in colour, egg-shaped in general outline, about one-quarter inch (6.25 mm.) long by one-eighth inch (3 mm.) broad; thorax deeply pitted, elytra striated, convex, deeply punctured in the striæ, slightly shiny; antennal segments hairy, arising from the rostrum, elbowed, tapering to a slight enlargement at the tip. The elytra, or wing covers, are fused together in a median line over the abdominal segments, consequently they are useless for flight and only serve for protection; they are hard and horny, overlying the abdominal segments laterally and at the extremity posteriorly; the legs are especially adapted for walking and are very strong. There is also a spur on the femur of each leg."[1]

LIFE-HISTORY

Oviposition.—The first eggs are laid in spring by overwintered adults. In our experiments it was found that such weevils collected in the field began to oviposit about the middle of May, the earliest date noted being May 13. Oviposition by these adults (which have overwintered) continues until the end of August, the eggs being produced at irregular intervals, depending greatly upon the temperature, very few or none at all being deposited when the weather is cool and an increase being observed as soon as the temperature rises. About

[1] Treherne, Ent. Bull. 8, Dom. Dept. Agr., Ottawa, 1914.

the end of May and the beginning of June adults begin to appear which have resulted from eggs laid the previous year and which have passed the winter as larvæ. These adults commence to deposit eggs in the middle of July, the earliest date noted being July 14th and continue to oviposit until autumn. Thus it will be seen that there are one-year-old weevils which have overwintered and also weevils which have recently emerged in the summer depositing eggs at the same time. The explanation of this doubtless lies in the fact that oviposition is not completed by the weevils in one season. This point has not yet been definitely proved owing to the fact that under laboratory conditions the weevils kept for observation failed to live through the winter, but it is probable that oviposition by the overwintered adults is simply a continuation of the oviposition of the previous summer and it is worthy of note that the weevils which were reared to adults in midsummer and kept for observation under isolation, have in no case failed to oviposit.

The number of eggs laid by the weevils after emergence in the summer has been found to average from 150 to 200 eggs per individual with a possible maximum of 300, the actual highest number obtained in the writer's experiments being 298. The overwintered adults of the previous year, on the other hand, laid comparatively few, the highest average obtained from them being 78 per individual in 1919 and 66 in 1920. Weevils emerging as adults in the summer continue to lay eggs rather later in the year than the overwintered ones, ceasing about the first week in September. The overwintered adults die shortly after their oviposition is completed. The eggs are deposited usually near the crowns of the strawberry plants and may be thrust into a crevice or dropped indiscriminately in the loose soil; they may sometimes be found at a depth of about a quarter of an inch. Incubation requires from fifteen to twenty-two days.

On hatching, the young larvæ at once commence to make their way down to the fine rootlets and the existence of a large root system is sufficient for the support of many larvæ. Coarse wiry roots will not sustain the young larvæ which will always be found during their early stages at a depth of from six to ten inches in the soil feeding on the fine roots of the plant. The largest number of grubs will always be found beneath the best developed plants, partly because the abundant shelter offered by the spreading leaves has attracted a greater number of adults for oviposition and also on account of the support given to a large number of larvæ by the root system. Apparently predacious insects do not play a very important part in reducing the numbers of the larvæ. Carabid beetles are present in fair numbers around the plants and the larvæ of therevid flies have been observed by the writer to destroy many grubs, but the number of these is insufficient to be a deciding factor in control. Certain small bugs belonging to the family *Lygaeidae* are often numerous around strawberry plants, and as some species of these are known to prey upon the eggs of insects they may effect a considerable reduction in the number of weevil eggs. It is the writer's belief that starvation of the grubs before they can reach suitable food is responsible for the destruction of the majority and, as is shown under control measures, starvation of the young grubs is the principal and most effective method of destroying the weevil.

The number of eggs laid around the plants must be very great inasmuch as it seldom happens that fewer than six adults are found sheltering around the crowns in the daytime and in severe infestations there may be from ten to twenty or more. This would mean a possible minimum of 1,800 eggs deposited but the number of larvæ that have been taken beneath the plants by the writer has never exceeded 120, though other investigators have claimed to have found many more. When so high a number as this is present every small root will be destroyed and very possibly the crown also may be attacked. But in average infestations the number of larvæ per plant will vary from ten to thirty, according to the age of the field. Usually when the plants are in vigorous health on good

land they are able to withstand the attack of a few larvæ and the presence of ten or a dozen will not prevent the production of an average crop, but when greater numbers than these are present they constitute a serious menace.

A small number of larvæ (those resulting from the earliest eggs) reach maturity by December but the majority will be found in a half grown state during the winter months. The larvæ apparently lie dormant during the winter and recommence feeding in the spring. It is then that the disastrous effect of their work is seen, for as they grow larger their feeding activities become greater, the roots of the plants being rapidly destroyed. Pupation commences about the middle of April, the larva making itself a small oval cell in the soil. The soft and delicate pupa is very susceptible to injury and its welfare greatly depends upon the cell remaining in a sound and unbroken condition. In experiments it was found that when the pupal cells were destroyed 72 per cent of the pupæ died. The duration of the pupal stage was found to vary from ten to twenty-six days.

FIG. 3.—Three-year-old strawberry plant stunted by weevil attack. Only hard fibrous roots remain. (Author's illustration)

The adult is at first pure milky white like the pupa but commences to harden at the end of twelve hours. At the end of twenty-four hours the colour has changed to a pale brown. Within seven to ten days the beetles are able to make their way to the surface of the soil. In experiments, the writer has known them to reach the surface in four days but they were not completely hardened. During the third week in May the adults commence to appear and are numerous around

the strawberry plants in the beginning of June. The date of their emergence varies greatly with the season and in a backward year their appearance may be delayed. In 1920 (a backward season) our earliest record was June 10. The beetles feed for about a fortnight before depositing eggs and so the life cycle commences anew.

Parthenogenesis.—A peculiarity which the Strawberry Root Weevil shares with other closely allied species is the fact that no males have ever been found. If males ever occur their presence would be abnormal and would have no influence upon the reproduction of the weevil. Reproduction is by parthenogenesis; that is to say, the females are able to produce fertile eggs independently of the presence of males. That this is so has been proved by the writer's experiments during recent years. In order to prove this point in the life-history, larvæ and pupæ were collected in the field and isolated, each being placed in a separate vial. After reaching the adult condition the weevils were kept isolated and fed and in due course each one produced fertile eggs which in no way differed in degree of fertility from those of adults collected indiscriminately in the field, thus showing normal parthenogenetic reproduction. Besides this, hundreds of dissections of weevils have been made but only females have been found. This fact of the weevils being all females explains in a great measure the reason for their rapid increase and the desirability of destroying as many adults as possible is quite apparent.

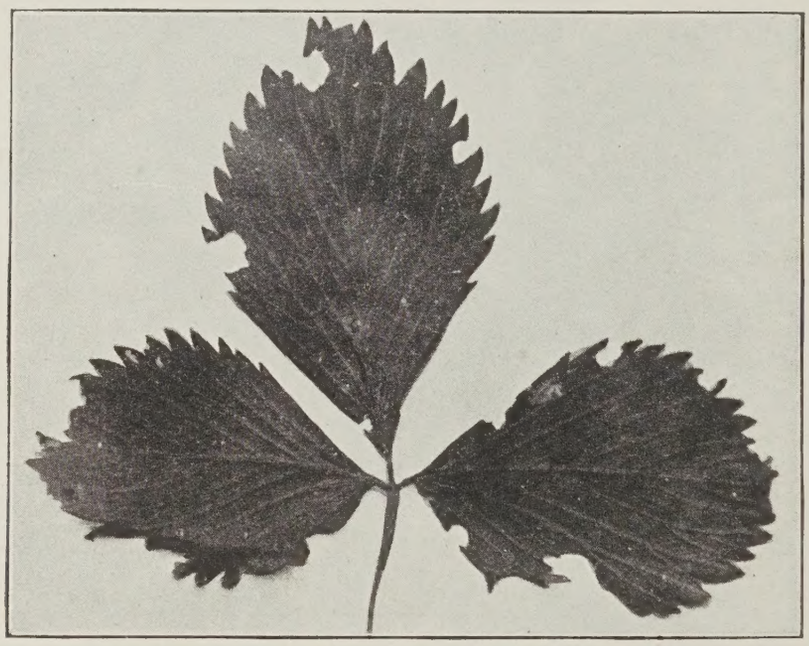

FIG. 4.—Leaf of strawberry showing characteristic injury caused by the feeding habits of the adult beetles. (After Treherne).

Food plants and feeding habits.—The adults feed and move principally at night and except in late summer, when there is a general migration away from the fields to search for winter quarters, not many are seen on the move in the day time. Their feeding activities are confined to nibbling the leaves of plants in a characteristic way but we have no record in British Columbia of any field having been seriously injured by their so doing. They are capable of feeding on almost any vegetation, strawberry leaves, clover, wild grasses and various weeds being given preference. It has been recorded by other observers that potatoes have been attacked, but this we have been unable to confirm in our experiments at Gordon Head, B.C.; in fact, unless pressed by hunger, we believe the weevil has a strong distaste for this plant.

As regards the plants upon which the grubs will feed the list is also a lengthy one and includes some of our fields crops and fruits. We quote the following list from Entomological Bulletin 8 (Dom. Dept. Agri., Ottawa):

Strawberry	Timothy
Blackberry	*Potentilla glandulosa*
Raspberry	White clover
Loganberry	Hemlock
Wild Strawberry	Balsam
Sorrel (*Rumex acetosella*)	Peach
Poa serotina	Potato?
Poa pratensis	Rhubarb?

It will be noticed that potato and rhubarb are included doubtfully. In my observations I have been unable to find any evidence to show that either of these crops is attacked. To the above-mentioned plants the following are added, upon the roots of which the larvæ have been found feeding:—

Red clover	Polyanthus
Oak	Periwinkle (*Vinca minor*)
Snowberry (*Symphoricarpus*)	Trefoil (*Trifolium dubium*)
Cabbage	Conifer seedlings

It is important to note that red clover is attacked. This fact was abundantly demonstrated at Gordon Head, B.C., when a plot of clover on the experimental ground was ploughed up. Larvæ were found in hundreds among the clover sods, in places nearly as numerous as they would be in a badly infested strawberry field. Therefore it is evident that a plantation of strawberries may easily become infested by weevils from a nearby clover field and to plant strawberries upon a ploughed-down clover sod would certainly be inadvisable. In arranging the disposition and rotation of the crops, therefore, only one safe course is possible to insure clean ground and that is to grow a non-host crop such as potatoes on the land intended for strawberries. Further reference to this is made under control measures.

Migrations.—The two principal migratory periods of the weevil are in the spring, when the adults leave winter quarters and move back again to the plantations and again in late summer, when the fall migration begins and the movement is away from the plantations to winter quarters. Our observations have not tended to show that there is any definite migration in mid-summer for the purpose of distributing eggs, but rather that there is simply a general movement of the weevils back and forth throughout the season. In June and July owing to the great increase in the number of weevils, it may be thought that a migration is in progress, but it is not until August that any decided general movement takes place. About this time the weevils begin to get restless and frequently enter houses in their search for winter quarters. This is especially the case after periods of dry, hot weather, and in suburban areas, where houses are situated near vacant lots or open grass land, they often cause considerable annoyance by entering dwellings in large numbers in search of shelter and moisture. They may hibernate in any conceivable spot that affords protection, under clods, stones, and among grass roots and piles of rubbish, while many do not leave the plants at all but may be found among the strawberry crowns throughout the winter. They are gregarious in habit and may often be found in hibernation clustered together in numbers. The movement back to the strawberry fields commences usually about the end of March, their activity being entirely governed by the state of the weather, a vigorous migration taking place upon the advent of the first warm spring days. Usually the weevils begin to bestir

themselves from March 15 to 20 in the Saanich district on Vancouver island, B.C., and from then until the end of April there is a steady return to the strawberry plantations.

Measures of Control

Recent studies of the life-history of the insect and the discovery of a new method of control by means of poisoned baits have simplified the problem of dealing with the weevil very considerably, and recommendations recently published require to be modified in some directions and changed in others. Many measures leading towards control have been tried and found ineffective, too expensive or unpractical. Among these may be mentioned, the application of soil insecticides, fumigants or chemicals; surface fumigation; repellants; spraying. Some success has been obtained by the use of barriers and traps. Lengthy experiments were carried out with various types of these at Gordon Head, B.C., but the expense and trouble entailed in erecting these is not warranted and throws them out of practical consideration, although such devices could probably be used to advantage in special cases or as an adjunct to other methods where extremely heavy infestations occur. Study of the life-habits of the weevil has shown that *cultural methods* (which includes ploughing of infested fields at the proper time of year and the adoption of a suitable rotation of crops), should take first place in the scheme of control, and a *poisoned bait* should be used to destroy any adult weevils which appear among the plants.

Cultural methods of control.—In reviewing the life-history of the insect, attention must be drawn to several points which have a bearing upon the course of action which we may follow in combatting the pest. Chief among these is the fact that although many thousands of eggs are deposited, yet comparatively few of the larvæ resulting from them seem to survive, the majority apparently dying if favourable conditions are not present, of which conditions the chief is an abundant supply of the right food. Therefore, the removal of the plants when the larvæ are quite small will result in their being starved, especially if care is taken to follow up the ploughing of the land with several weeks of careful cultivation. The method to be adopted then, when an infested field is to be cleaned up is as follows: After the berries have been picked the straw may be left on the ground and the plants untouched until fall. The object of this is to induce as many weevils as possible to deposit their eggs in the field instead of migrating. Were the plants removed immediately the crop was picked, there would be a general exodus of weevils to the nearest plantation. The straw provides excellent cover for the weevils and would be a further inducement to them to remain.

In the case of fields which are not seriously infested and from which another crop of berries is to be taken, the straw may be burned, if desired. From the point of view of weevil-control the practice has little or no value, as the insects usually manage to bury themselves in the soil in sufficient time to escape. If burning the straw is carried out it should be done as soon as possible after the berries are picked, and it would be well to rake the straw into the space between the rows as otherwise some plants may be injured by the fire. Many people gather up the straw and use it for bedding down stock or other purposes, but in the case of badly infested fields this is not a practice to be recommended as large numbers of weevils are gathered up with the straw and transported to other parts of the farm. Many of these will hibernate and attack the nearest strawberry patch the following spring.

Towards the end of August or early in September the plants may be lifted and burned. The field should then be ploughed and to remove any small strawberry roots and to keep down weeds, thorough cultivation should be continued at intervals for a month or six weeks. As the weevil does not cease egg-laying

until September it will not be advisable to plant any crop until a sufficient time has elapsed for the eggs to hatch and the larvæ to be killed. The land may then be sown to some fall crop according to the scheme of rotation which it is desired to follow. It has been proved beyond question during our experiments at Gordon Head, B.C., that this plan, if properly carried out, will destroy all the larvæ in the soil. Land that had been heavily infested on the experimental ground was dealt with in the above manner and when ploughed again in the spring was thoroughly examined for larvæ but not one could be found; similar results have been obtained in other fields as well and private growers have also found the above measures most effective.

Rotation of crops.—The constant cropping of land with strawberries cannot be too strongly condemned. Such a practice not only exhausts the soil but is responsible for a tremendous increase and concentration of weevils and other strawberry pests. In a general way it may be said that not more than two successive crops of berries should be taken off before planting the land to some other crop. In any method of rotation in which strawberries are included care must be taken that a non-host crop such as potatoes should precede the strawberry crop and thereby insure against the land being infested before the strawberry plants are set out. It is manifestly impossible to lay down any definite rule or suggest a scheme of rotation that will be applicable to every farm or section of country. The most that can be said is that such a scheme of rotation should be planned so as to maintain the soil fertility and to have non-host crops precede the strawberry crop.

Recent developments, however, in weevil control by means of poisoned bait give the grower much more latitude as regards crop rotation. While it is true in general that in order to secure clean land a non-host crop should precede the strawberry crop, this rule may be departed from where weevils are few in numbers and there are no heavily infested places close by. Past experience has shown that the best fields of strawberries are often obtained by planting after clover sod, but in the event of this being done care must be taken that the field is thoroughly baited as soon as the plants are set out and again in June, as described further on in this pamphlet.

The following alternative rotations are suggested according to the circumstances prevailing. Where the land is new and in good heart a six-year rotation as shown below might be used.

1st year—plant strawberries.
2nd year—1st crop berries.
3rd year—2nd crop berries, plough and plant fall wheat.
4th year—fall wheat with clover.
5th year—clover sod, manure if possible.
6th year—potatoes, prepare land for strawberries the following spring.

Or again, if the grower has a piece of sod land or old land which requires cleaning up, the following might be used:—

1st year—potatoes or other hoed crop, plough and plant fall wheat with vetches.
2nd year—plough crop under when in bloom and summer-fallow.
3rd year—plant strawberries.
4th year—1st crop berries.
5th year—2nd crop berries, plough and plant fall wheat, seed to clover in spring.

Poisoned baits.—While cultural methods provide a certain means of ensuring a clean field to begin with and the practice of a proper system of rotation will do much in the way of control, yet the most careful cultivation will not prevent the fields being re-infested by migrations of weevils from adjoining land. Or,

weevil grubs may be present in the soil when the field is planted and will emerge as adults during the first year so that sufficient eggs will be laid to provide a heavy infestation before the first crop is harvested. It is obvious, then, that some means of destroying the adults is most desirable. Several methods have been tried in the past but the most successful has been by means of poisoned bait.

The raisin and shorts bait.—To make this bait 50 pounds of raisins are soaked in 5 quarts of water for from six to twelve hours. The time for soaking varies somewhat according to the condition of the raisins, some being much drier than others. Five pounds of sodium fluosilicate is then mixed thoroughly with 50 pounds of shorts and both are then mixed with the raisins from which the surplus water has been drained away. The mixture should then be put through a large-sized butcher's mincer which is set to cut coarsely. The crank must be turned slowly to prevent the mixture from heating and jamming the machine. The process of mincing crushes and cuts the raisins and the juice is mixed with the shorts, the resultant bait being a slightly moist crumbly mash. The mixture should be sufficiently moist to form a ball when squeezed in the hand. Too much moisture should not be used or the bait may heat and become mouldy. Spoiled raisins which have been in storage too long can frequently be obtained in large quantities at a low price. In our experiments only the sultana variety has been used, the seeded raisins, being stuck together in a mass, having been found too difficult to handle.

As regards the poison which may be used we have found that sodium fluosilicate (commercial grade) is the most suitable and effective. The first poisoned bait to be used for strawberry root weevils contained magnesium arsenate and other poisons have been used with success, such as calcium arsenate, sodium fluoride and zinc arsenite. Arsenicals, however, are all more or less repellent to insects. This was indicated in some of our experiments in which, when a bait mixed with an arsenical gave poor results, the same bait mixed with sodium fluosilicate often gave a very good kill. Moreover, it has been found that when dried apple containing about 20 per cent moisture is used as the attractant the bait becomes very sticky and difficult to handle when arsenates are used as the poison. This stickiness develops two or three days after the bait has been mixed and is apparently caused by the arsenical forming a hygroscopic compound with the apple.

Sodium fluosilicate is not repellent to insects and forms no hygroscopic compound when used in poisoned baits of any kind. It is a by-product of acid phosphate manufacture and has recently come into prominence as an insecticide. For use in poisoned baits it possesses some advantages over arsenicals, one of which is the fact that it is by far less poisonous to man and higher animals. Approximately nine times as much sodium fluosilicate would be required to poison a human being or an animal as any of the ordinary arsenicals in common use. But to insects it is decidedly more poisonous and in our experiments it has given the best and most consistent results of any poison we have tried. It is only slightly soluble in water and baits in which it is used should be able to resist the effect of a little rain.

Sodium fluoride has also been used by us with considerable success in some cases, but being less toxic than sodium fluosilicate more of it requires to be used. In some of our tests it gave very good results, but being soluble the bait is more likely to be affected by rain and, in general, it is not as valuable a poison for weevils as sodium fluosilicate. It may be used where sodium fluosilicate cannot be obtained, but the amount of poison used should be increased to seven per cent.

Other attractants.—It is probable that other kinds of dried fruit which can be obtained cheaply and in quantity could be used to advantage as attractants. In our experiments at Gordon Head, dried prunes were used in one experiment and found equal to raisins in attractiveness. On account of the stones, however, no means was found at that time of handling this material economically. If this difficulty could be surmounted waste prunes could be used as an alternative to raisins since it is possible in certain seasons when the prune crop is large to obtain quantities of low grade or waste prunes at a nominal price. In hot dry weather weevils are attracted to almost any moist bait containing sugar and during such weather a good kill is obtained with whatever bait is used. In early spring, during moist, cool weather, the bait is not eaten so readily and the kill is proportionately less.

The cost of weevil bait.—The cost of the bait in British Columbia will vary according to the materials used and the supply available. From time to time low grade raisins which have been in storage too long can be obtained for about 6 cents per pound. At current prices in British Columbia the approximate cost of the material per pound would then be—$\frac{1}{2}$ pound raisins, 3 cents; $\frac{1}{2}$ pound shorts, $\frac{3}{4}$ of a cent; sodium fluosilicate, 1 cent; total $4\frac{3}{4}$ cents per pound.

To make a small quantity of bait.—To make a small quantity of bait, about 20 pounds, the following method may be used: soak 10 pounds of raisins in 2 pints of water until the water is absorbed. They should be coarsely chopped in a household food chopper and then mixed with 10 pounds of shorts in which 18 ounces of sodium fluosilicate has previously been mixed, stirring or rubbing the mixture between the hands until the shorts has taken up all the juice. Where sodium fluosilicate cannot be obtained, 20 ounces of sodium fluoride may be substituted but the results may not be quite so good.

Caution as to the use of sodium fluosilicate.—The dust of this chemical is very irritating to the mucous membranes of the nose and throat and care should be taken not to breathe the dust when mixing. Where large quantities have to be mixed the safest course is to wear some form of respirator or gas mask.

The time and method of applying weevil-bait.—To obtain the best results, two applications of bait require to be made. Since a large number of weevils overwinter and return to the fields in spring to deposit eggs, an application of bait must be made to destroy these and another requires to be made in June to destroy the new generation which emerges from the soil at that time. The first application should be made about the middle of April and the second from the middle to the end of June, depending somewhat upon the season and the time the weevils appear on each individual farm. While on some farms they may begin to appear in numbers at the beginning of the month, on others they may be much later. The grower should be on the lookout for this summer generation and act accordingly. By lifting one or two plants he can ascertain whether the weevils are still in the grub stage or turning to beetles and nearly ready to emerge. It is desirable to destroy the adult beetles before they have a chance to lay any eggs, which they will begin to do within ten days or a fortnight after emergence.

Whatever kind of bait is used the method of application is the same. About 1 tablespoonful is dropped down in the centre of each strawberry plant. It should not be scattered around the plants, because by far the largest number of weevils are hidden during the daytime around the crowns, and by dropping the bait in the centre of the plants they will reach it more readily. About 100 pounds of bait are required for 1 acre; young plants will require less because few weevils are usually present on a newly-planted field. The bait should be applied in dry warm weather whenever possible, because the weevils are then more active and because rain injures the efficiency of the bait.

The raisin-shorts bait is easy to apply. No mechanical contrivance, as suggested for applying some baits, is necessary. A little of it should be taken and squeezed in the hand and the mass thrown into the centre of each plant, where it breaks. All bending is thereby obviated and the field can be quickly covered. The bait should not be too dry but should be a moist, crumbly mash. If too dry when purchased, add a little water before using. The bait, when mixed with sodium fluosilicate, keeps fairly well in storage, but it is safer to use it soon after mixing. We have, however, kept sacks of it piled on one another for three months without moulding.

Summary

(1) The strawberry root weevil is a native insect abundant everywhere; the larvæ live on the roots of grasses, clovers and other plants. The strawberry is a favourite food plant. The insect makes its appearance wherever this crop is grown.

(2) Control measures consist in the adoption of a suitable system of rotation of crops so that the plantation can be started on a clean field, and the application of a poisoned bait twice a year, commencing when the plants are first set out.

(3) The proper time to apply the bait is in the middle of April for the first application to destroy the overwintering weevils, and from the middle to the end of June for the second application, to destroy the summer generation which appears about that time. The second application of bait is the one which is most important.

Fig. 5.—Black vine weevil; grub at left; adult beetle in centre; pupa at right. Hair line indicates natural size. (After Gibson and Ross)

THE BLACK VINE WEEVIL (*Brachyrhinus sulcatus* Fab.)

This is another weevil that is prevalent in the strawberry fields associated with the Strawberry Root Weevil. From our observations, however, it is not nearly so destructive. It is seldom found in such great numbers, nor is it so generally distributed in strawberry fields, being quite absent from some farms. The range of its food plants is as great as that of the Strawberry Root Weevil and it is frequently reported as doing damage in gardens. The life-history is similar and reproduction is by parthenogenesis as in the case of the latter insect.

The adult beetle is black, shiny, speckled with patches of yellow hairs on the elytra; length three-eighths of an inch; thorax densely tuberculate, the elytra striated and rugose. As in the case of *B. ovatus* the wing covers are fused together and the weevil is incapable of flight.

The larva is creamy-white, about three-eighths of an inch in length, tapering, curved; the head is pale brown; the back is wrinkled and furnished with a few short hairs. Previous to pupation the larva forms an oblong cell in the soil. These cells average 9 mm. by 15 mm., being considerably larger than the pupa which does not exceed 10 mm. in length. The pupa is pure white, soft and delicate, but capable of a certain amount of lateral movement, wriggling energetically when disturbed. It was noticed that in confinement the pupæ were seriously injured by the destruction of the pupal cells, especially if this occurred during the critical period at the commencement of pupation when the integument was particularly delicate and susceptible to injury. As regards oviposition, individuals kept in confinement have laid as many as 470 eggs with an average of 300 per weevil.

B. sulcatus matures somewhat earlier than *B. ovatus* and in our experiments appeared nearly a week earlier than the latter. It is not so important economically as *B. ovatus*, and where proper rotation of crops is conducted and the land not allowed to remain in strawberries too long, it is not likely to cause serious trouble.

THE STRAWBERRY CROWN MINER (*Aristotelia fragariæ* Busck)

Frequently, in addition to weevils, strawberry plantations suffer from the attacks of a mining caterpillar which bores in the crown. Often there is little indication of the presence of the insect except that the plants are less vigorous than unaffected ones and there is a serious diminution in the amount of fruit. Less foliage is produced and the leaves show a tendency to redden in the fall and die down more quickly. On examination of the crowns the presence of larvæ can be detected by the brick-coloured dejecta on the outside of the crowns at the entrance to the galleries. The tunnels made by the larvæ allow moisture to enter and the lower parts of the crowns rot and sometimes break off. Within the root the larval galleries run in all directions and extend frequently to the whorl of leaves at the tip of the crown and the base of the leaf petioles. The number of larvæ found in a crown varies from one to four. Occasionally crowns will be found to contain many more than this and as many as twelve larvæ have been taken in a three-year-old crown. Occasionally an empty pupal case may be found protruding from the old galleries. Invariably the greatest number of larvæ are found in old plants.

The egg.—The following description is quoted from the "Biennial Crop Pest and Horticultural Report," Experimental Station, Corvallis, Oregon, 1913: "The eggs are deposited on the sheaths about the crown, on the underside of the leaves, and along the leaf petioles. They are usually pushed well down among the fine hairs. The egg is white with a dull lustre, a slight area at the smaller end being transparent. The surface of the egg is ribbed and pitted, very much resembling the hull of a peanut. The egg is elongate, flattened at the larger end, the edges rounded. From the base it gradually increases in size to near the middle, then slopes down to a blunt rounded point. It measures .55 mm. long and .29 mm. wide."

The larva.—Larvæ were found to be full-grown in October. They measured 7 mm. in length and 1 mm. to 1.2 mm. in width. In colour they are generally bright pink on the dorsum, except the first segment, which is white, the pink colour becoming deeper on the anal segments. The venter is white, the head pale brown. They are very active and wriggle out of their burrows when disturbed, moving backwards or forwards with equal facility and hanging by a thread of silk when they drop. During the winter the larva lines the sides of

its burrow with silk for a distance of at least twice its own length, both ends of the silken case being open, and in this it spends the winter and spring months. It was not observed whether the larvæ fed much in the spring but they did not increase in size and were always to be found in their hibernacula, which they occupied until May, when they left to take up positions for pupation.

The first pupa was taken on June 1 and about that time the larvæ were found to be contracted and quiescent, preparing to pupate. Sometimes pupation took place at the exit of the burrows near the head of the crown; at other times the larvæ were found at exits half way down the root, but the majority were taken among the dead stipules at the tip of the crown, a passage to which had been bored some time previously. The pupal chamber is silk-lined, but not so heavily as in the case of the hibernaculum.

The pupa.—The pupa measures approximately 4 mm. in length and 1.25 mm. wide. It is light brown in colour. The wing cases are large and the tips reach to the penultimate abdominal segment. The abdominal segments have each a few short bristles and the anal segment is furnished with several longer hairs.

FIG. 6.—Strawberry crown miner; showing burrows in strawberry crown. (After Lovett)

The adult.—The moth expands 11 mm. It is grey in colour, slightly speckled with darker grey. The forewings have the outer margin rounded, the fringe extending from the extremity of the costal margin to half way along the lower margin. The secondaries have a longer fringe, more apparent on the lower margin. The first moth was taken in the emergence cages on June 23. Three were taken on July 1 and the number emerging gradually increased until the maximum was reached on July 11, when 21 moths emerged. From then on the number declined, until July 27, after which no more emerged.

The moth is a weak flier and when disturbed during the day does not move very far. It is active at first, making short flights from point to point and when followed attempts concealment by alighting on the soil or among rubbish where it is exceedingly difficult to see and may easily be overlooked. During the day the moth avoids the light, hiding deep down among the dead leaves and petioles of the strawberry crowns.

Degree of Infestation and Methods of Control

The greatest number of larvæ can always be taken in plants that have been in the ground for three or four years. One thing is certain, a concentration of the pest is found in fields that are allowed to remain in strawberries for too long a period. The average number of moths that emerged from 23 plants taken from a three-year-old field at Sidney, B.C., was 4.3 per plant. In two-year-old plants the infestation was very much lower, though it varied in different localities, some plantations showing as high as one or two larvæ per root, while others would be entirely free. Thus it would seem that the same methods of control as advocated for checking the attacks of the Strawberry Root Weevil would be effective in keeping the Crown Miner in check; that is to say, not more than two crops should be taken from a plantation before a change of crop is made. Whenever the plants are lifted they should be stacked and burned. No parasites of the moth have been observed.

THE WESTERN 10-LINED JUNE BEETLE

[*Polyphylla ruficollis* Csy. (*decemlineata* Say)]

This insect has been only partly studied and considerable work will need to be done before its life-history is thoroughly known. In the grub stage it is frequently very destructive, not only to strawberries, but also to the roots of fruit trees, and to corn and potatoes. Normally the habitat of the beetle is in sandy areas near bush where the grubs feed on the roots of grasses and

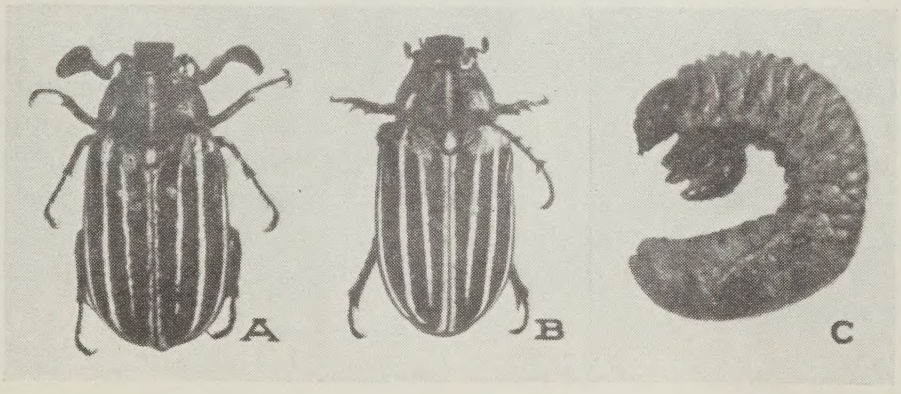

Fig. 7.—Western 10-lined June beetle; A, male; B, female; C, grub. (Original)

herbaceous plants and to some extent on tree roots. Often when fruit trees, especially cherries, are taken out, the grubs of this beetle will be found. They prefer sandy soil as this is easily penetrated and in a strawberry field or in a row of corn a grub will work along below the surface destroying one plant after another. In certain years they may be very numerous and then they are capable of working destruction on a wholesale scale in a strawberry field. The usual evidence of their work is the sudden wilting of the plants and on examination these will be found to be cut through not far from the surface. It is thought that the larval stage of these beetles lasts for three years.

When examining plants on a plantation that was badly infested a female adult was taken in the soil about two inches below the surface and in captivity laid a few eggs which, however, proved to be infertile. They measured 3 mm. in length by 2 mm. in width, oval, smooth, and pure white in colour.

The full-grown larva measures, when fully extended, two inches in length, and is half an inch wide. Invariably it is found in a curved position, the caudal half of the body being beneath. The head is brown; the dorsum is wrinkled,

but the caudal segments of the body are smooth and dark coloured from the contents of the intestine showing through. When full grown the grub forms a large oval cell in the soil in which it transforms to a pupa and later emerges as a perfect insect during the latter half of July. The emergence holes are usually from 6 inches to 1 foot away from the plants on which the grub has been feeding.

The adult beetle measures one and one-quarter inches in length and nearly five-eighths of an inch wide. The head and legs are reddish; the thorax dark reddish speckled with minute yellow scales. A white stripe extends down the centre of the thorax and there are two other stripes, one on either side. The wing cases are each marked longitudinally with four parallel white stripes and between these stripes the dark brown surface is speckled densely with minute yellow scales which give a yellowish appearance to this part of the body The under surface of the thorax is densely hairy, the abdomen being smooth.

Control measures. It is difficult to suggest any remedy for this pest that will be effective other than digging the grubs out and destroying them. Badly infested fields should be ploughed up and hogs or chickens turned in, and these will be especially useful when ploughing is in progress as the grubs bury themselves in the soil again shortly after being disturbed. Every effort should be made to destroy the grubs, as owing to their omnivorous habits the succeeding crop is liable to be attacked in turn if the larvæ still remain in the soil.

It is a good plan to have someone follow the plough and pick up the grubs. As infestations in strawberry fields are usually at first of limited extent, the most practicable plan in such cases is to dig over these spots as soon as the injury is noticed and destroy all the grubs; otherwise they will soon increase the damage by travelling along under the surface of the soil from one plant to another.

In experiments conducted by Mr. A. A. Dennys, Dominion Entomological Branch, at Creston and Edgewood, B.C., some success in poisoning the grubs was attained by ploughing in a mixture of bran and sodium fluosilicate, the proportions used being 1 pound of sodium fluosilicate to 12 pounds of bran, mixed dry. The mixture may be scattered in a furrow alongside the row and turned under or a handful may be dropped into a hole 6 inches deep between the plants. Sodium fluoride may be substituted where sodium fluosilicate cannot be obtained.

THE STRAWBERRY CROWN MOTH

[*Synanthedon bibionipennis* Bdv. *(rutilans* Hy. Edw.)]

This moth is not sufficiently numerous in British Columbia to be seriously troublesome, but it is widely distributed and has been found at Gordon Head and in the Okanagan valley, B.C., and as it may occur wherever strawberries are grown a description of the insect is given.

The presence of the insect in a strawberry crown is revealed by the sickly appearance of the plant which, on being pulled up, often breaks off at the crown exposing the gallery made by the larva. The latter is a yellowish-white grub about half an inch in length and nearly one-eighth of an inch wide. Sometimes it may be slightly tinted with pink. In July the larva bores to the top of the crown and constructs a brown cocoon out of frass and silk, which projects slightly from the end of the burrow. When the emergence of the adult takes place the pupa works half way out of the cocoon and after the moth has emerged the pupa case is left projecting from the cocoon or occasionally drops to the ground.

The moth.—The male moth expands 16 mm. The forewings are dark brown with a central transparent area interrupted by a square black spot. The hind wings are transparent bordered with brown. Both wings carry fringes of black on the outer margin. The thorax is black with two longitudinal yellow stripes; the abdomen is black with two narrow yellow bands. The anal tuft is black and yellow. The legs are yellow; the hind femora are furnished with two pairs of spurs and have a black band at the junction of the tibiae.

FIG. 8.—Strawberry crown moth; 1 larvæ in crown of strawberry, (After Essig); 2, male and female moth. (Original)

The female which expands about 18 mm. has four yellow bands on the abdomen and is stouter than the male. The transparent areas of the forewings are slightly smaller and there is also rather more yellow in the anal tuft.

Control measures.—Affected plants should be pulled up and burned. Otherwise the general rules outlined for strawberry growing, such as crop rotation and the avoidance of the practice of taking off more than two crops, should keep this pest under control.